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Ω_b^-

DØ Collaboration

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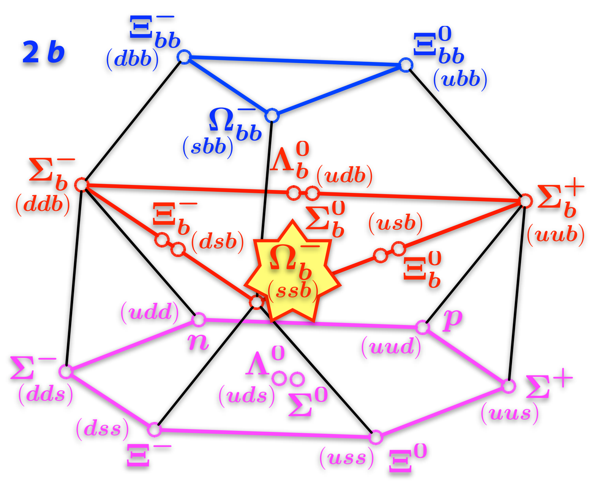
Observation of the Doubly Strange b–baryon Ω_b^-

On behalf of the DØ Collaboration • Jesus Orduna • CINVESTAV IPN, Mexico City

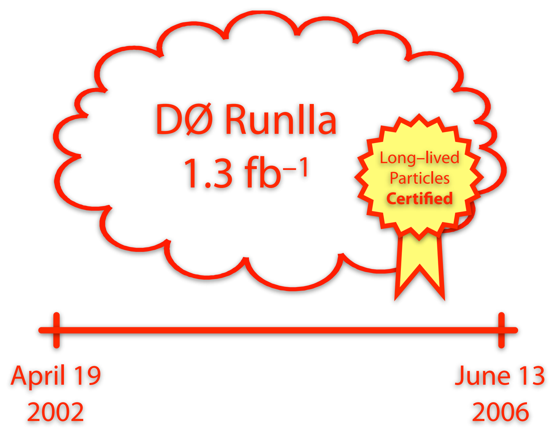
I. b–Baryons with $J = ½$

The family of particles made of three quarks is known as baryons.

b–Baryons are those containing at least one b quark. In this case we look at those having a total angular momentum J equal to ½.



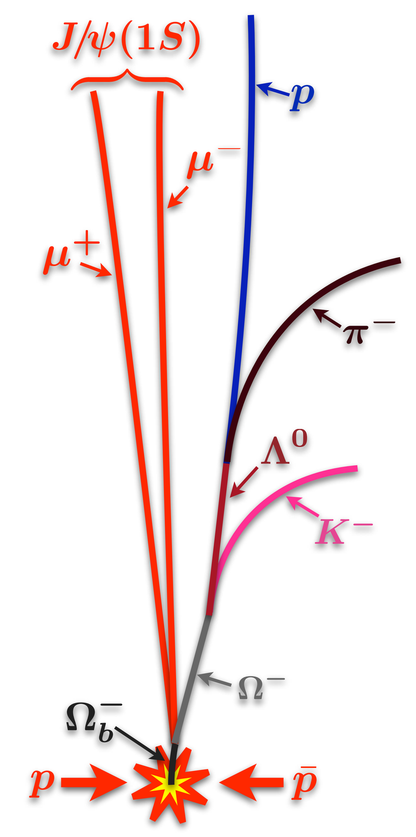
II. Data



This analysis was performed with 1.3 fb⁻¹ of data collected in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV with the DØ detector [1], at the Fermilab Tevatron Collider.

These data was reprocessed with an extended tracking reconstruction code to increase the identification efficiency of long–lived particles such as the Ω^- (sss).

III. Decay & J/ψ selection



We look for the Ω_b^- in the following decay mode:

$$\Omega_b^- \to J/\psi\ \Omega^-$$

with

$$J/\psi \to \mu^+\mu^-,\quad \Omega^- \to \Lambda K^-$$

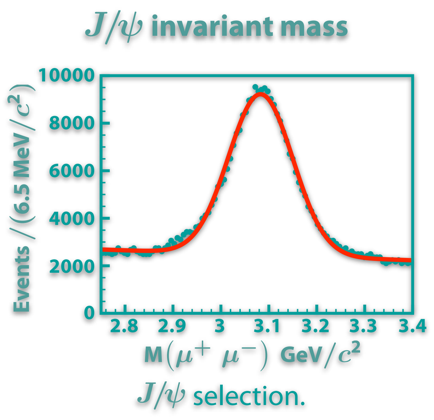
and

$$\Lambda \to p\pi^-.$$

Its topology is schematically depicted on the figure.
We took initial information from both, theory and the accumulated experience from the analysis which led to the first observation of the Ξ_b^- (dsb), in the summer of 2007 by DØ [2], which have a similar decay chain.

J/ψ

With the information from the central tracking system and the calorimeter, we select two opposite–charge muons coming from a common vertex.
The reconstructed $p\bar{p}$ interaction point is the one we take as the production vertex for the Ω_b^-.

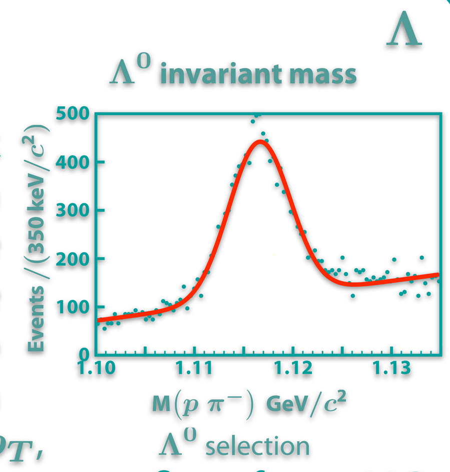


J/ψ selection.

IV. Λ optimization

Λ

Once we have selected J/ψ's, we look for two opposite–charge tracks with a common vertex to form a Λ. We apply some restrictions to these tracks and the vertex in order to reduce the Λ background as much as we can. The track with the higher p_T, is assumed to be the proton as we confirm from MC studies.



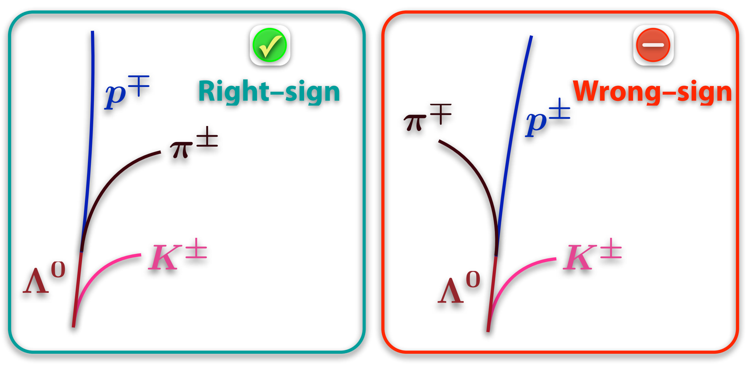
Λ^0 selection

$\Lambda K^\pm$

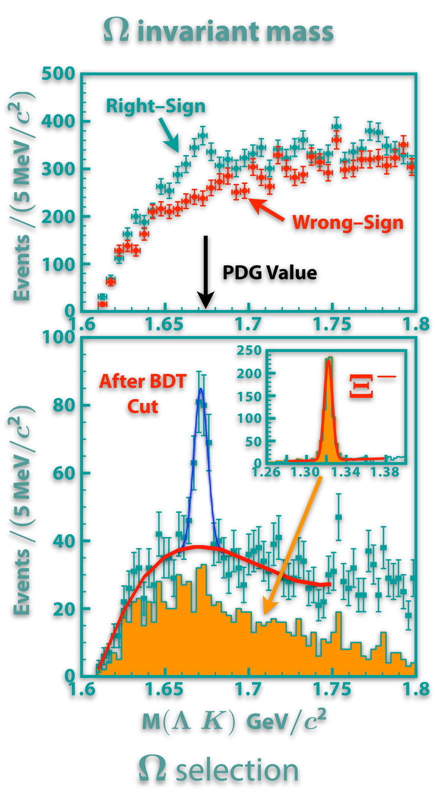
Resulting Λ's are combined with an extra track, which is assumed to be a K. Depending on the charge of the K, we define two separate sets:

- K and π charge match. To form Ω^- candidates.
- K and π with opposite charge. To optimize and background studies.

Using the wrong–sing we find an optimum cut in the Λ's proper decay length significance that allows us to clean the signal without the direct use of the right–sign candidates.



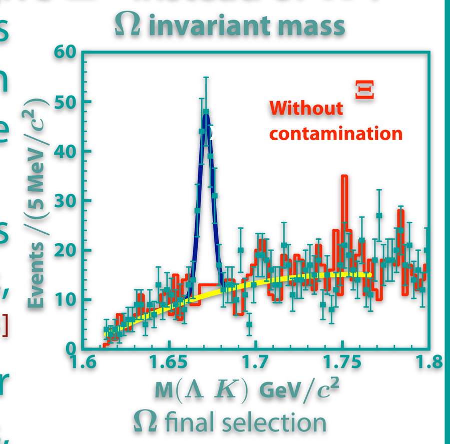
V. Ω^-



Ω selection

We use multivariate analysis techniques [3] to clean the combination ΛK.
A BDT classifier with 20 variables takes into account the most important characteristics of the final particles to improve the quality of the Ω signal.
To train the BDT, we use $\Omega^\pm \to \Lambda\ K^\pm$ MC events from $\Omega_b^\pm \to J/\psi\ \Omega^\pm$ decays as signal and wrong–sign combinations as background.
Due to their similar decay topologies, we investigate the possibility of assign a K mass to an actual π track which would give Ξ^- instead of Ω^-.

After removing possible Ξ^-events, is evident that only the correct–sign combination shows an excess in the number of Ω^- candidates.



Ω final selection

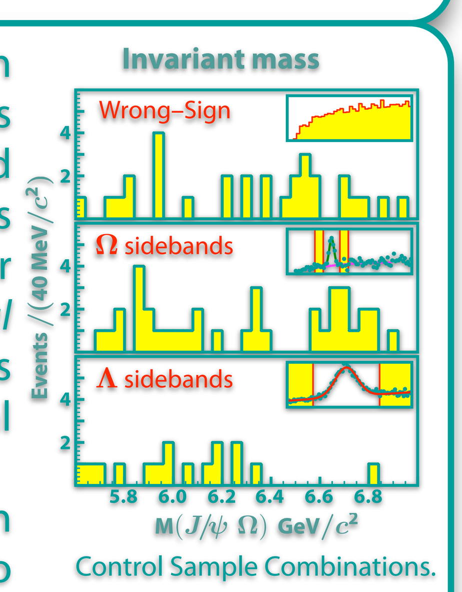
As in the Ξ_b^- analysis [2], the mass definition for the resulting candidates, combines constructed and reported[3] masses for the J/ψ, $\Omega^-$and their combination. Applied to MC events, we reproduce the input mass used at generation level. We also see an improvement in the MC mass resolution with:

$$\mathrm{M} = \mathrm{M}(J/\psi\ \Omega^-) - \mathrm{M}(J/\psi) - \mathrm{M}(\Omega^-) + \hat{\mathrm{M}}(J/\psi) + \hat{\mathrm{M}}(\Omega^-)$$

M's are reconstructed while $\hat{\mathrm{M}}$'s are reported in [3].

VI. Final Combination

The final combination with all selection criteria, was made first taking various samples where we don't expect to find any signal like wrong–sign, sidebands and MC from b–decays with similar topologies; to test for an *"artificial production"* due to the method. As expected, we don't see any signal where it is not supposed to be.

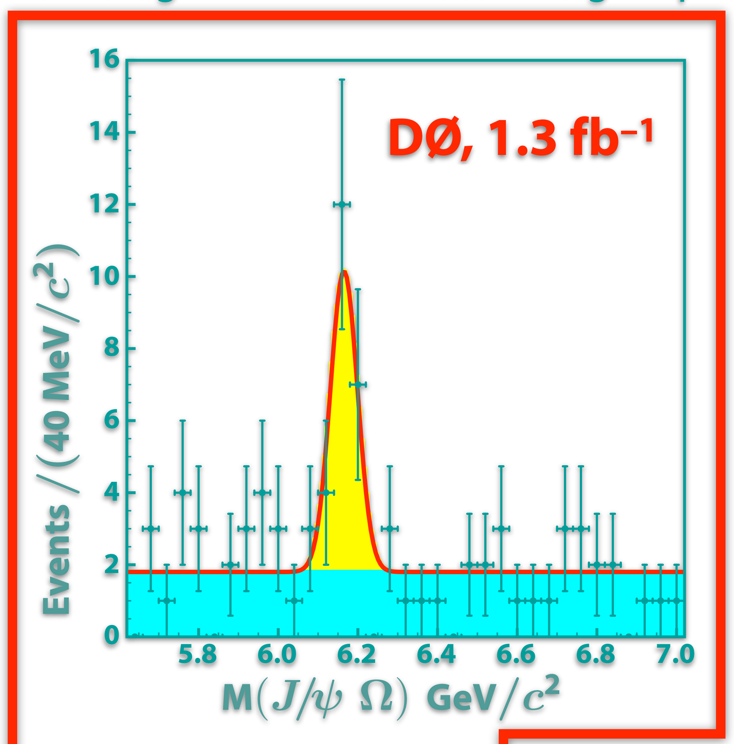


Control Sample Combinations.

In the correct combination, we see an excess of events. We report the fit to this histogram with a Gaussian signal plus a flat background, but we also tried various other hypothesis about signal and background shapes. Our main source of systematic error comes from the variation in the selection criteria.
Finally, we use the logarithmic likelihood ratio:

$$\sqrt{2\ln\frac{\mathcal{L}_{S+B}}{\mathcal{L}_B}}$$

to determine the significance of the signal.



Observed signal.

VII. Result [5]

Using 1.3 fb⁻¹ of data collected with the DØ detector from $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV, at the Fermilab Tevatron Collider, we find 17.8 ± 4.9 (stat) ± 0.8 (syst) Ω_b^- events following the decay chain $\Omega_b^- \to J/\psi(\mu^+\mu^-)\ \Omega^-(\Lambda[p\pi^-]K^-)$.
We obtain a mass of 6.165 ± 0.010 (stat) ± 0.013 (syst) GeV/c^2 with a significance of $5.4\,\sigma$. All other hypothesis used to model signal and background also give a significance above $5.0\,\sigma$.
The probability of the signal coming from a fluctuation in the background is 6.7×10^{-8}.
This is the first experimental evidence of the Ω_b^- in this particular decay channel.

References

[1] V. M. Abazov *et al.* (DØ Collaboration), Nucl. Instrum. Meth. A **565**, 463 (2006).
[2] V. M. Abazov *et al.* (DØ Collaboration), Phys. Rev. Lett. **99**, 052001 (2007).
[3] A. Höcker *et al.*, arXiv:physics/0703039.
[4] C. Amsler *et al.* (Particle Data Group), Phys. Lett. **B667**, 1 (2008).
[5] V. M. Abazov *et al.* (DØ Collaboration), Phys. Rev. Lett. **101**, 232002 (2008).
[6] T. Aaltonen *et al.* (CDF Collaboration). arXiv:hep–ex/0905.3123

Real Event

The figure shows the 2D projection of one of the events we found consistent with the reconstruction of the Ω_b^-.
We have identified each one of the final particles as well as the reconstructed intermediate states.
The cross section of the central tracking has been superimposed. The red points correspond to hits in the Silicon Microstrip Tracker (SMT), in blue those belonging to the Central Fiber Tracker (CFT) and in green we have identified some of the hits used to reconstruct the specific tracks.

Run 203929. Event 22881065.
$\mathrm{M}(\Omega_b^-) = 6.158$ GeV/c^2